CLAIMS

1.   A method for optimising an expression tree, said expression tree for compositing an image and comprising at least two nodes, each said node of said tree being either a graphical element or a graphical operator and having a region of the image represented by said node, the method comprising, for at least one node in said tree, the steps of:

comparing the region represented by said node to a region representation data structure corresponding to one or more regions represented by at least one other node;

determining if the region represented by said node is totally or partially obscured by said one or more regions; and

modifying the expression tree in the event that the region represented by said node is at least partially or totally obscured.

2.   The method as recited in claim 1, wherein the step of modifying the expression tree includes applying a clipping operator to said node in the event the region represented by said node is partially obscured.

3.   The method as recited in claim 1, wherein the step of modifying the expression tree when said node is totally obscured further includes the steps of:

if the node is a graphical element, removing the node; and

if the node is a graphical operator, applying a predetermined set of node replacement rules in accordance with said graphical operator.

4.   The method as recited in claim 3, wherein said predetermined set of node replacement rules comprises at least one step selected from the group consisting of:

if the parent node is an "over" graphical operator and the current node is at a left branch of the parent node, replacing the parent node with a right subtree of the parent node;

if the parent node is an "over" graphic operator and the current node is at a right branch of the parent node, replacing the parent node with a left subtree of the parent node;

if the parent node is an "in" graphical operator, removing the parent node and any subtrees branching off the parent node;

if the parent node is a "ratop" graphical operator and the current node is at a left branch of the parent node, removing the parent node and any subtrees branching off the parent node;

if the parent node is a "ratop" graphical operator and the current node is at a right branch of the parent node, replacing the parent node with a left subtree of the parent node;

if the parent node is an "out" graphical operator and the current node is at a left branch of the parent node, removing the parent node and any subtrees branching off the parent node;

if the parent node is an "out" graphical operator and the current node is at a right branch of the parent node, replacing the parent node with a left subtree of the parent node;

if the parent node is a "plusC" graphical operator and the current node is at a left branch of the parent node, replacing the parent node with a right subtree of the parent node;

if the parent node is an "plusC" graphical operator and the current node is at a right branch of the parent node, replacing the parent node with a left subtree of the parent node;

if the parent node is a "plusW" or an "Xor" graphical operator and the current node is at a left branch of the parent node, replacing the parent node with a right subtree of the parent node; and

if the parent node is an "plusW" or an "Xor" graphical operator and the current node is at a right branch of the parent node, replacing the parent node with a left subtree of the parent node.

5.   The method as recited in any one of claims 1 to 4, wherein the graphical operators are image compositing operators.

6.   The method as recited in claim 1, wherein the region representation is of the form of a hierarchical data structure.

7.   The method as recited in claim 6, wherein the hierarchical data structure is a quadtree representation.

8.   A method of optimising an expression tree for compositing an image, said expression tree comprising a plurality of nodes each said node being either a graphical element or a graphical operator and having a region of the image represented by said node, said method comprising the steps of:
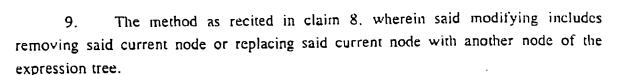
traversing the expression tree node by node;

determining at a current node if a region of the image represented at said current node is obscured by regions represented by at least one other node, and modifying said expression tree in the event that the current node is partially or totally obscured.

9.   The method as recited in claim 8, wherein said modifying includes removing said current node or replacing said current node with another node of the expression tree.

10.   The method as recited in claim 8, wherein said modifying further includes clipping, or marking for clipping at a later time, the region represented by said current node.

11.   A method of optimising an expression tree for compositing an image, said expression tree comprising a plurality of nodes, each said node comprising either a graphical element or a graphical operator and having a region of the image represented by said node, said method comprising the of:

traversing the expression tree node by node and at each current node comprising a graphical operator applying the sub-steps of:

(i)   receiving a first region representation from a parent node;

(ii)   passing to a first operand of said graphical operator a modified first region representation in accordance with a first predetermined modification rule for said operator;

(iii)   returning to the graphical operator a second region representation of regions obscured by a sub-tree associated with the first operand;

(iv)   passing to a second operand of said graphical operator a modified second region representation in accordance with a second predetermined modification rule for said operator;

(v)   returning to the graphical operator a third region representation of regions obscured by a sub-tree associated with the second operand; and

(vi) determining, in accordance with a set rule for said graphical operator, a final region representation to be returned to the parent node.

12.   The method as recited in claim 11, wherein said set rule is selected from the group consisting of:

(a)   where the graphic operator is an "over" or a "plusC" operator, the final region representation to be returned to the parent node is determined from a union of the second region representation and the third region representation;

(b)   where the graphic operator is an "in" operator, the final region representation to be returned to the parent node is determined from an intersection of the second region representation and the third region representation;

(c)   where the graphic operator is an "ratop" operator, the final region representation to be returned to the parent node is the second region representation;

(d)   where the graphic operator is an "out" operator, the final region representation to be returned to the parent node is determined from a difference of the second region representation and a region representation comprising at least a region represented by a bounding box of a node at a right subtree of the current node; and

(e)   where the graphic operator is an "Xor" or a "plusW" operator the final region representation to be returned to the parent node is determined from a union of the second region representation less a region representation comprising at least a region represented by a bounding box of a node at a right subtree of the current node and the third region representation less a region representation containing a bounding box of a node at a right subtree of the current node.

13.   The method as recited in claim 11, wherein the first predetermined modification rule comprises:

passing substantially the first region representation as the modified first region representation in the event that the graphical operator is an "over", "in", "ratop", "plusC", "plusW", "Xor", "out" (visit left operand first)" or alike operators; and

if the graphical operator is an "out (visit right operand first)" operation, passing as the modified first region representation a union the first region representation with the second region representation.

14.   The method as recited in claim 11, wherein the second predetermined modification rule comprises:

passing substantially the first region representation as the modified second region representation in the event that the graphical operator is an "in", "ratop", "out", "plusC", "plusW", "Xor" or alike operators; and

in the event that the graphical operator is an "over" operator passing as the modified second region representation union of the first region representation with the second region representation.

15.   The method as recited in any one of claims 11 to 14 wherein the image representation is not created at a node, or returned to a parent node of said node, unless said image representation is subsequently utilised.

16.   The method as recited in claim 15, wherein the image representation is not created at a node or returned to the parent node if the node is selected from a group consisting of:

a right operand of an "over" operator and the "over" operator node does not need to return an image representation to its parent node;

a left operand of an "in", "plusC", "plusW" or "Xor" operator and said operator node does not need to return an image representation to its parent node;

a right operand of an "in", "plusC", "plusW" or "Xor" operator and said operator node does not need to return an image representation to its parent node

5   a left operand of an "out" or "ratop" operator and said return an image representation to its parent node;

a right operand of a "ratop" operator;

a root of the expression tree;

an operand of an image warp, affine transformation or convolution operator;

10   an operand of a colour transformation that does not preserve opaqueness or if said transformation node does not need to return an image representation to its parent node.

17.   An apparatus for optimising an expression tree, said expression tree for compositing an image and comprising at least two nodes, each said node of said tree being either a graphical element or a graphical operator and having a region of the image represented by said node, the apparatus comprising:

means for comparing the region represented by said node to a region representation data structure corresponding to one or more regions represented by at

20   least one other node;

means for determining if the region represented by said node is totally or partially obscured by said one or more regions; and

means for modifying the expression tree in the event that the region represented by said node is at least partially or totally obscured.

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18.   The apparatus as recited in claim 17, wherein the modifying means includes means for applying a clipping operator to said node in the event the region represented by said node is partially obscured.

30   19.   The apparatus as recited in claim 17, wherein the modifying means comprises:

means for removing the node if the nodes is a graphical element and the node is totally obscured; and

means for applying a predetermined set of node replacement rules in accordance

35   with said graphical operator if the node is a graphical operator and the node is totally obscured.

20.   The apparatus as recited in claim 19, wherein said predetermined set of node replacement rules comprises at least one step selected from the group consisting

of:

if the parent node is an "over" graphical operator and the current node is at a left branch of the parent node, replacing the parent node with a right subtree of the parent node;

5   if the parent node is an "over" graphic operator and the current node is at a right branch of the parent node, replacing the parent node with a left subtree of the parent node;

if the parent node is an "in" graphical operator, removing the parent node and any subtrees branching off the parent node;

10   if the parent node is a "ratop" graphical operator and the current node is at a left branch of the parent node, removing the parent node and any subtrees branching off the parent node;

if the parent node is a "ratop" graphical operator and the current node is at a right branch of the parent node. replacing the parent node with a left subtree of the

15   parent node;

if the parent node is an "out" graphical operator and the current node is at a left branch of the parent node, removing the parent node and any subtrees branching off the parent node;

if the parent node is an "out" graphical operator and the current node is

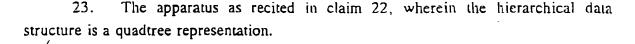20   at a right branch of the parent node, replacing the parent node with a left subtree of the parent node;

if the parent node is a "plusC" graphical operator and the current node is at a left branch of the parent node, replacing the parent node with a right subtree of the parent node;

25   if the parent node is an "plusC" graphical operator and the current node is at a right branch of the parent node, replacing the parent node with a left subtree of the parent node;

if the parent node is a "plusW" or an "Xor" graphical operator and the current node is at a left branch of the parent node, replacing the parent node with a

30   right subtree of the parent node; and

if the parent node is an "plusW" or an "Xor" graphical operator and the current node is at a right branch of the parent node, replacing the parent node with a left subtree of the parent node.

35   21.   The apparatus as recited in any one of claims 17 to 20, wherein the graphical operators are image compositing operators.

22.   The apparatus as recited in claim 17, wherein the region representation is of the form of a hierarchical data structure.

23. The apparatus as recited in claim 22, wherein the hierarchical data structure is a quadtree representation.

24. An apparatus for optimising an expression tree for compositing an image, said expression tree comprising a plurality of nodes each said node being either a graphical element or a graphical operator and having a region of the image represented by said node, said apparatus comprising:

means for traversing the expression tree node by node;

10 means for determining at a current node if a region of the image represented at said current node is obscured by regions represented by at least one other node;

means for modifying said expression tree in the event that the current node is partially or totally obscured.

15 25. The apparatus as recited in claim 24, wherein said modifying means includes means for removing said current node or replacing said current node with another node of the expression tree.

26. The apparatus as recited in claim 24, wherein said modifying means
20 further includes means for clipping, or marking for clipping at a later time, the region represented by said current node.

27. A apparatus for optimising an expression tree for compositing an image, said expression tree comprising a plurality of nodes, each said node comprising either a
25 graphical element or a graphical operator and having a region of the image represented by said node, said apparatus comprising:

means for traversing the expression tree node by node, said traversing means. for each current node comprising a graphical operator, further comprising:

means for receiving a first region representation from a parent
30 node;

means for passing to a first operand of said graphical operator a modified first region representation in accordance with a first predetermined modification rule for said operator;

means for returning to the graphical operator a second region
35 representation of regions obscured by a sub-tree associated with the first operand;

means for passing to a second operand of said graphical operator a modified second region representation in accordance with a second predetermined modification rule for said operator;

means for returning to the graphical operator a third region representation of regions obscured by a sub-tree associated with the second operand; and

means for determining, in accordance with a set rule for said graphical operator, a final region representation to be returned to the parent node.

28. The apparatus as recited in claim 27, wherein said set rule is selected from the group consisting of:

(a) where the graphic operator is an "over" or a "plusC" operator, the final region representation to be returned to the parent node is determined from a union of the second region representation and the third region representation;

(b) where the graphic operator is an "in" operator, the final region representation to be returned to the parent node is determined from an intersection of the second region representation and the third region representation;

(c) where the graphic operator is an "ratop" operator, the final region representation to be returned to the parent node is the second region representation;

(d) where the graphic operator is an "out" operator, the final region representation to be returned to the parent node is determined from a difference of the second region representation and a region representation comprising at least a region represented by a bounding box of a node at a right subtree of the current node; and

(e) where the graphic operator is an "Xor" or a "plusW" operator the final region representation to be returned to the parent node is determined from a union of the second region representation less a region representation comprising at least a region represented by a bounding box of a node at a right subtree of the current node and the third region representation less a region representation containing a bounding box of a node at a right subtree of the current node.

29. The apparatus as recited in claim 27, wherein the first predetermined modification rule comprises:

passing substantially the first region representation as the modified first region representation in the event that the graphical operator is an "over", "in", "ratop", "plusC", "plusW", "Xor", "out" (visit left operand first)" or alike operators; and

if the graphical operator is an "out (visit right operand first)" operation. passing as the modified first region representation a union the first region representation with the second region representation.

30. The apparatus as recited in claim 27, wherein the second predetermined modification rule comprises:

passing substantially the first region representation as the modified second region representation in the event that the graphical operator is an "in", "ratop", "out", "plusC", "plusW", "Xor" or alike operators; and

in the event that the graphical operator is an "over" operator passing as the modified second region representation union of the first region representation with the second region representation.

31.   The apparatus as recited in any one of claims 27 to 30 wherein the image representation is not created at a node, or returned to a parent node of said node, unless said image representation is subsequently utilised.

32.   The apparatus as recited in claim 31, wherein the image representation is not created at a node or returned to the parent node if the node is selected from a group consisting of:

a right operand of an "over" operator and the "over" operator node does not need to return an image representation to its parent node;

a left operand of an "in", "plusC", "plusW" or "Xor" operator and said operator node does not need to return an image representation to its parent node;

a right operand of an "in", "plusC", "plusW" or "Xor" operator and said operator node does not need to return an image representation to its parent node

a left operand of an "out" or "ratop" operator and said return an image representation to its parent node;

a right operand of a "ratop" operator;

a root of the expression tree;

an operand of an image warp, affine transformation or convolution operator;

an operand of a colour transformation that does not preserve opaqueness or if said transformation node does not need to return an image representation to its parent node.

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